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FACTS ABOUT THE UNITED STATES ANTARCTIC RESEARCH PROGRAM

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Division of Polar Programs

NATIONAL SCIENCE FOUNDATION
Washington, D.C. 20550

July 1982

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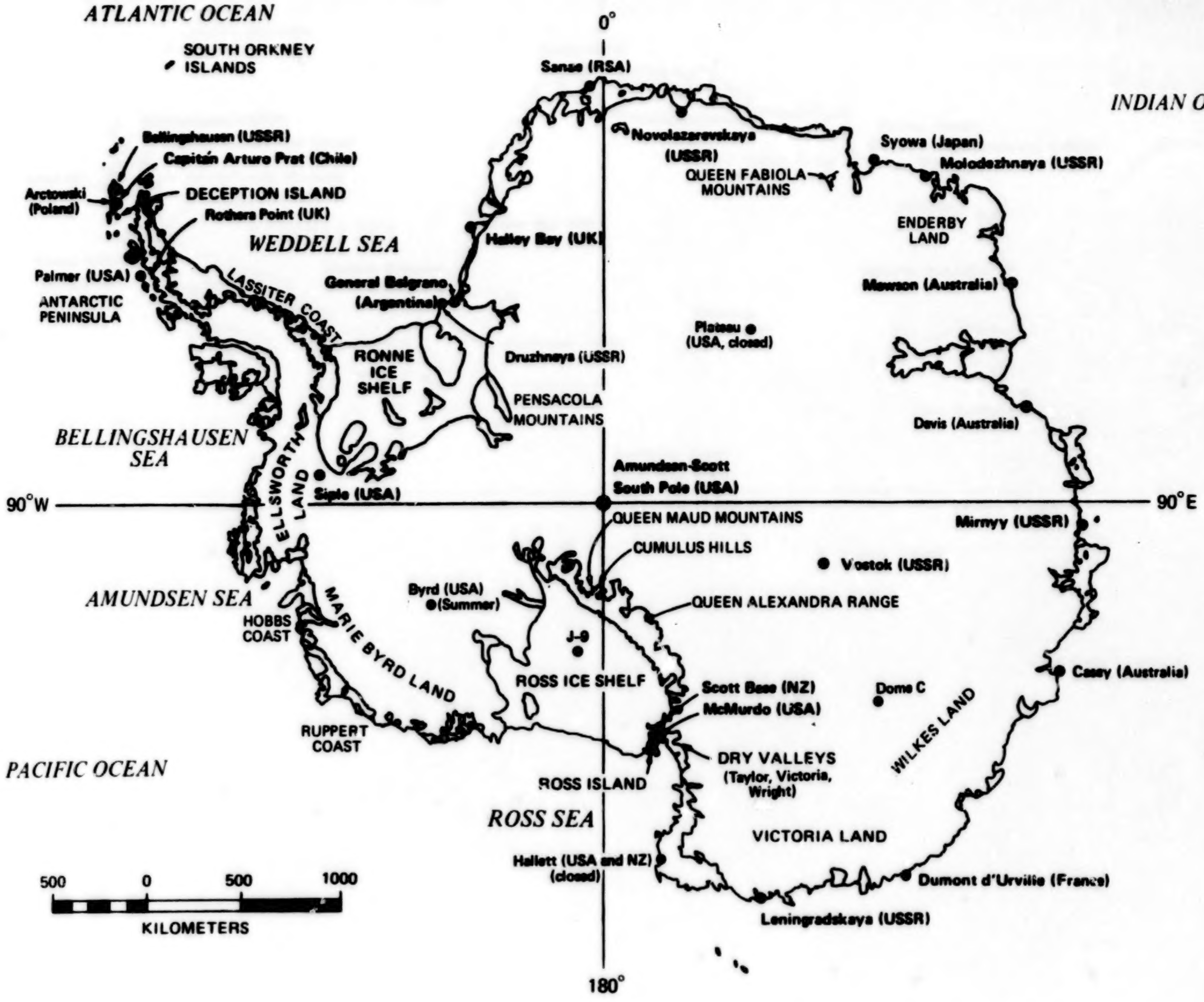

ANTARCTICA: selected stations and physical features.

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FACTS ABOUT THE UNITED STATES ANTARCTIC RESEARCH PROGRAM

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Introduction

More than 1,000 Americans work in and around Antarctica each year in the United States Antarctic Research Program. This National program involves the operation of ships, aircraft, stations, and camps, and it draws upon the resources and scientists of numerous U.S. universities, a number of Federal agencies, and several commercial firms. This pamphlet provides a digest of the operation: facilities in Antarctica, objectives, Federal responsibilities, the substantial international aspects, and a brief history of prior U.S. activities. A final section provides sources of further information.

I. Physical description of Antarctica

An ice sheet covers nearly all of Antarctica. At its thickest point the ice sheet is 15,670 feet deep—almost 3 miles. It averages 7,000 to 8,000 feet thick, making Antarctica the highest continent. This ice is 90 percent of all the world's ice, and it is 70 percent of all the world's fresh water.

The Transantarctic Mountains cross the continent, dividing the ice sheet into two parts. The larger, eastern ice sheet rests on land that is mostly above sea level. It has been there at least 14 million years. The smaller, western ice sheet is on land that is mostly below sea level.

Other mountain ranges are the Prince Charles Mountains and smaller groups near the coasts. The Antarctic Peninsula has many mountains. The Ellsworth Mountains are Antarctica's tallest; the Vinson Massif is 16,066 feet above sea level.

About 2 percent of Antarctica is ice-free. These areas, generally near the coast, include the dry valleys of southern Victoria Land, the Bunger Oasis in Wilkes Land, and isolated spits of land.

Surrounding Antarctica are the southern parts of the Pacific, the Atlantic, and the Indian Oceans. The Antarctic Convergence, which encircles Antarctica roughly a thousand miles off the coast, divides the cold southern water masses and warmer northern waters. An ocean current, the world's largest, moves eastward around the continent at an average speed of about half a knot. Sea ice up to 10 feet thick forms outward from the continent every winter, making a belt 300 to 1,000 miles wide. Even in summer the sea ice belt is 100 to 500 miles wide in most places.

Some 200 million years ago Antarctica was joined to South America, Africa, India, and Australia in a single large continent called Gondwanaland. There was no ice sheet, and trees and large animals flourished. Today, only geological formations, coal beds, and fossils remain as clues to Antarctica's warm past.

Antarctica is the coldest continent. The world's record low temperature of -126.9°F was recorded there. The mean annual temperature of the interior is -70°F. The coast is warmer. Monthly means at McMurdo Station range from -18°F in August to 27°F in January. Along the Antarctic Peninsula, temperatures as high as 59°F have been recorded.

Some coasts of Antarctica are the windiest places in the world. Winds on the Adelie Coast in the winter of 1912-1913 averaged 40 miles an hour, and gusts have been recorded at nearly 200 miles an hour.

The interior of Antarctica is one of the world's major deserts, with the precipitation (if it were melted) averaging 1 to 2 inches of water a year.

II. Currently active year-round U.S. stations

A. *McMurdo* (*77°51'S 166°40'E*). America's largest antarctic station, McMurdo is built on the bare volcanic rock of Hut Point Peninsula on Ross Island, the farthest south solid ground that is accessible by ship. It is the logistics hub of the United States Antarctic Research Program, with a harbor, landing strips on sea ice and shelf ice, and a helicopter pad. Its 130 buildings range in size from a small radio shack to large, three-story structures. Science laboratories, repair facilities, dormitories, administrative buildings, a firehouse, power plant, water distillation plant, wharf, stores, clubs, and warehouses are linked by above-ground water, sewer, telephone, and power lines. The station was established in December 1955. Local features include Mount Erebus (an active volcano), McMurdo Sound (the station's namesake, named for Lt. Archibald McMurdo of James Clark Ross's 1841 expedition), the Ross Ice Shelf, and the ice-free (dry) valleys of southern Victoria Land. Recorded temperature extremes have been -50C (-58F) and 8C (47F). Annual mean is -18C (0F); monthly mean temperatures range from -3C (27F) in January to -28C (-18F) in August. Drifting snow can accumulate about 1.5 meters (5 feet) per year, although the station becomes snow-free in summer. Average wind is about 5.1 meters per second (10 knots); a gust of 52 meters per second (101 knots) was recorded in July 1968. Research is performed at and near McMurdo in marine and terrestrial biology, biomedicine, geology and geophysics, glaciology and glacial geology, meteorology, and upper atmosphere physics. Peak summer population can exceed 850; winter population is about 92. The winterers are isolated from late February to late August and from then to October. Transportation to New Zealand is frequent between October and February—the antarctic summer.

B. *Amundsen-Scott South Pole* (*90°S*). Americans have occupied the geographic South Pole continuously since November 1956; the station was rebuilt in 1975 as a geodesic dome 50 meters wide and 16 meters high that, with 14- by 24-meter (46 by 80 foot) steel archways, covers modular buildings, fuel bladders, and equipment. Two detached buildings house instruments for monitoring the upper and lower atmosphere. There is an emergency camp. Some 17 scientists and support personnel winter at the station, and 50 or more people work there during the summer. Recorded temperature has varied between -13.6C (3.1F) and -82C

(-117F). Annual mean is -49C (-56F); monthly means vary from -28C (-18F) in December to -60C (-76F) in July. Average wind is 6.1 meters per second (12 knots); peak gust recorded was 24 meters per second (47 knots). Snow accumulation is about 6-8 centimeters (2-3 inches) (water equivalent) per year. The station stands at an elevation of 2,835 meters (9,300 feet) on interior Antarctica's nearly featureless ice sheet, about 2,850 meters thick at that location. Research at the station includes glaciology, geophysics, meteorology, upper atmosphere physics, astronomy, and biomedical studies. The station's name honors Roald Amundsen and Robert F. Scott, who attained the South Pole in 1911 and 1912. The station is isolated between mid-February and early November.

C. ***Siple*** *(75°55'S 83°55'W)*. In Ellsworth Land at the base of the Antarctic Peninsula, Siple is the smallest and newest of the U.S. year-round station locations. It was established in 1969, enlarged and first occupied year-round in 1973, and, because of high snow accumulation that distorted the original structure, built anew in 1979. Twenty-four connected prefabricated building modules are located under a steel arch measuring 13 by 80 meters (43 by 262 feet). By 1981 the annual snowfall of about 1.7 meters (5.6 feet), along with drifting, covered the 7-meter-high arch of the new station. The floor of the disused 1973 station was 17 meters (57 feet) below the snow surface in 1981. Temperature extremes at Siple are -52C (-62F) and 7C (44F). Annual mean is -24C (-11F); monthly averages range from about -35C (-31F) in August to -12C (10F) in January. Winds average 6.5 meters per second (13 knots); a wind of 33 meters per second (65 knots) was recorded in October 1980. The station elevation is 1,000 meters (3,300 feet); ice thickness is slightly less than that.

Upper atmosphere physics is pursued at Siple. The station features a horizontal antenna 21 kilometers (13 miles) long, a radio receiver, and a transmitter for studies in the very-low-frequency range. Siple was placed where it is for study of signals transmitted along magnetic lines of force that extend from Siple as far as four earth radii into space, returning to earth at Siple's geomagnetic conjugate point in the northern hemisphere—the thunderstorm-rich region of southeastern Quebec. During large projects in summer, Siple's population may reach 65. Wintering complement is normally eight, but has been as small as four.

Siple Station is named for Paul Siple, a polar expert who headed the first wintering science party at the South Pole in 1957 and first went to Antarctica as a Boy Scout with Richard E. Byrd in 1928.

D. ***Palmer*** *(64°46'S 64°03'W)*. Palmer Station, on a protected harbor on the southwestern coast of Anvers Island, off the Antarctica Peninsula, is the only U.S. antarctic station north of the Antarctic Circle. The temperature is mild, with monthly averages ranging from -10C (14F) in July and August to 2C (36F) in January and February. The annual mean is -3C (26F). The extreme range is -31C (-24F) to 9C (48F). It rains every month at Palmer; in the year ended October 1981 Palmer received 25 centimeters (10 inches) of rain and 36 centimeters (14 inches) (water equivalent) of snowfall.

The station, built on solid ground, consists of two major buildings and three small ones plus two large fuel tanks, a helicopter pad, and a dock. Construction was completed in 1968, replacing a prefabricated wood structure ("Old Palmer," established in 1965) 2 kilometers away across Arthur Harbor. Old Palmer is still used in summer. Somewhat over 40 people can occupy Palmer in the summer. Wintering population is about 10.

Palmer Station is superbly located for biological studies of birds, seals, and other components of the marine ecosystem. It has a large and extensively equipped biological laboratory and sea water aquaria. Meteorology, upper atmosphere physics, glaciology, and geology also have been pursued at and around Palmer. The station operates in conjunction with ***Hero***, a research trawler described under Transportation and research platforms, below.

Palmer Station is named for Nathaniel B. Palmer, a Connecticut sealer who, on 17 November 1820, during an exploratory voyage ranging southward from the South Shetland Islands, may have been the first person to see Antarctica. (British and Russian ships were in the area at about the same time.) Nathaniel Palmer's 14-meter sloop was named the ***Hero***.

III. Summer camps

A. ***Byrd Surface Camp*** ***(80°S 120°W)***. On the site of the former Byrd Station (a major under-snow research facility operated year-round from early 1957 to February 1972) Byrd Surface Camp is operated during the summer as a fuel stop and weather station for planes flying between McMurdo and Siple Stations. Typical summer population is eight personnel. The camp consists of sled-mounted modules, which can be easily moved.

B. ***Dome C*** *(74°30'S 123°10'E)* camp is comprised of Jamesways (wood-framed and wood-floored buildings covered with insulated canvas blankets that can be erected or disassembled in several hours) in East Antarctica at an elevation of 3,425 meters (11,200 feet). The ice at that location is over 4,200 meters thick. Dome C is one of the three major ice domes of the east antarctic ice sheet (the others are Dome B and Dome A). Glaciology is the major discipline pursued at Dome C, which is reached by airplane from McMurdo Station. Dome C camp was established in 1974-1975.

C. ***Major camps***. Approximately every other year, the United States Antarctic Research Program establishes and operates a major summer research camp in an area of particular scientific interest. Typically these camps consist of Jamesways, and they support a population of 40 to 60 during the November-January period. Three helicopters are taken to the site and used to support local scientific operations. Motor toboggans also are operated. Such camps have been operated in recent years in northern Victoria Land (1981-1982), the Ellsworth Mountains (1979-1980), at Darwin Glacier in the Transantarctic Mountains (1978-1979), and in the mountains of northern Marie Byrd Land (1977-1978). Geology, geophysics, glacial-geology, glaciology, and terrestrial biology have been pursued at these camps.

D. *Huts.* If summer research projects are expected to continue over several seasons at the same location, wood huts may be erected. Huts can be expected to last for several years, and they provide space, stable working areas, and comfort not achievable with tents. Huts have been used in recent years in Taylor Valley (an ice-free or dry valley in southern Victoria Land) for study of lake ecosystems, at Cape Crozier on Ross Island for population and behavioral studies of penguin rookeries, and near the summit of Mount Erebus for volcanology. Resupply and transport are by helicopter or tracked vehicle from McMurdo Station.

E. *Tents.* Small parties requiring temporary shelter use double-walled tents of several designs, including the Scott tent, a pyramid shaped tent similar to the design used by Robert F. Scott early in this century. These tents are stable in high winds and can be erected quickly. Cold-weather sleeping bags are used on ground cushions, and cooking is by portable stoves. Tent camps usually are placed or moved by helicopter or motor toboggan. Backpacking generally is not practical in Antarctica owing to the weight of equipment and the weight of fuel required to combat the cold. All tent camps and huts are required to have radios, and they maintain daily contact with the nearest station.

IV. Former stations (selected)

A. *Hallett Station (72°19'S 170°13'E)* on Cape Hallett on the northeast coast of Victoria Land, was operated jointly with New Zealand from 1957 to February 1973, particularly for biological studies. It shared a point of land with a large penguin colony. Cape Hallett was named by James Clark Ross for a member of his 1841 expedition.

B. *Byrd Station (80°S 120°W)*, 1957-1972, was a large under-snow facility in Marie Byrd Land for upper atmosphere physics, meteorology, geophysics, and glaciology. It was closed because the scientific usefulness of a facility at the location had diminished and because the increasing snow load was crushing the station. The station's name honors Richard E. Byrd.

C. *Plateau Station (79°15'S 40°30'E)* was the highest, coldest, and most remote of the U.S. stations. It was operated from December 1965 to January 1969. Situated in the middle of the east antarctic ice plateau at an elevation of 3,625 meters (11,900 feet), the station recorded a climate typical of several million square kilometers of central Antarctica. Temperatures ranged from -18.5C (-10F) down to -86.2C (-123F), just short of the world record low of -88.3C (-126.9F) recorded at the Soviet station Vostok, Antarctica. Annual mean at Plateau was -56.4C (-70F). Snow accumulation was about 3 centimeters (1 inch) (water equivalent) a year, putting the plateau among the great deserts of the world.

Plateau Station was established for meteorology, geophysics, and upper atmosphere physics. The station comprised five prefabricated vans assembled into a building 8 by 25 meters plus an additional van and a Jamesway for emergency shelter. A tower, 32 meters high, was equipped with 10 sensors of wind speed, wind direction, and temperature. Station population was eight during winter.

D. *Eights Station (75°10'S 77°10'W)* was 200 kilometers east-northeast of Siple Station. It operated from January 1963 to January 1965, mainly in support of upper atmosphere physics. Station population during winter was 10-11. The station was named for James Eights, who in 1830 was the earliest American scientist in the Antarctic.

E. *Little America.* There were five Little Americas, all on the Ross Ice Shelf adjacent to the Bay of Whales or Kainan Bay. Numbers I and II supported Richard E. Byrd's expeditions in 1928-1930 and 1933-1935. III was operated in 1939-1941 as part of the United States Antarctic Service and was also called West Base. IV was used by Operation Highjump, 1946-1947. V was an International Geophysical Year station, operating from 1955 to 1959. All these stations have gone to sea as a result of calving of the Ross Ice Shelf.

F. *East Base (68°11'S 67°00'W)* is the oldest existing U.S. station in Antarctica. It is on Stonington Island near Marguerite Bay, on the west coast of the Antarctic Peninsula. The United States Antarctic Service established East Base in March 1940 as one of its two stations (the other was West Base, or Little America III), and 26 men wintered. There was a main building, 7 by 18 meters, and several smaller buildings along with a biplane, a tractor and a tank, and sledge dogs. The expeditioners left in March 1941. The (U.S.) Ronne Antarctic Research Expedition occupied the base during the winter of 1948. Americans last visited East Base on 10 and 11 February 1975 and found three of the original buildings still standing.

V. Transportation and research platforms

A. *LC-130 Hercules.* This four-engine turboprop transport airplane is the backbone of U.S. transportation within Antarctica, and it also provides much of the air service between McMurdo Station and New Zealand. The LC-130 is the polar version of the familiar C-130 cargo plane; its major unique feature is the ski-equipped landing gear, which enables operation on smooth snow or ice surfaces throughout Antarctica. The plane also has wheels for landings on prepared hard surfaces. It was introduced to the antarctic program in 1960; the fleet currently numbers seven. The plane has a cargo area 12 by 3 by 3 meters (41 by 9 by 9 feet). It can, as an example, carry 12,200 kilograms (27,000 pounds) of people and/or cargo from McMurdo to South Pole (728 nautical miles), then return to McMurdo without refueling. Or, it can deliver 10,400 kilograms (23,000 pounds) from McMurdo to Siple (1,280 nautical miles), fly back empty to Byrd (484 miles) for fuel, then return to McMurdo. It cruises at 275 knots (500 kilometers per hour). Wingspan is 40 meters; length overall, 30 meters (132.6 by 97.8 feet). One of the planes is equipped for meteorological sensing, and can be equipped for radioecho sounding of ice thickness, aerial photography, and other scientific observations.

B. *UH-1N helicopter.* Six or seven of these twin-turbine helicopters are operated out of McMurdo Station during the austral summer. With an operating weight of 3,200 kilograms (7,000 pounds), the UH-1N can carry a payload of 730 kilograms (1,600 pounds) or up to five passengers over an operating radius of 185 kilometers (100 nautical miles). Using an external cargo sling, it can carry 1,400 kilograms (3,000 pounds). Cruising air speed is 100 knots (185 kilometers per hour).

C. *Icebreakers*. Two classes of U.S. icebreakers operate in Antarctica (see table below). The *Polar*-class is America's newest and most powerful icebreaker. Either the *Polar Star* or the *Polar Sea* deploys to Antarctica each year to resupply Palmer Station, break a channel through McMurdo Sound, and support research in and near the pack ice. *Glacier deploys every year for icebreaking, escort services, and support of science projects. The Wind*-class icebreakers served in Antarctica until the 1979-1980 season.

U.S. Coast Guard Icebreakers

	Polar-class built 1976-77	*Glacier built 1955*	*Wind-class built 1944-47*
Length (m)	122	94	82
Displacement (met. tons)	13,401	8,915	6,604
Max. hp.	60,000	21,000	10,000
Max speed (k)	17	17	16
Cr. speed (k)	13	12	10.5
Range (n. mi.)	28,000	25,000	38,000
Personnel	154	213	190
Helicopters (HH-52)	2	2	2
Cargo (measurement tons)	400	0	0
Scientists	10	18	6-9

D. *USNS Maumee*. Each year this ice-strengthened tanker or its sister USNS *Yukon* delivers approximately 20,000,000 liters of diesel fuel arctic (DFA), jet fuel (JP-4), and gasoline to McMurdo Station.

E. *USNS Southern Cross*. Annual visits by this or a similar ship deliver cargo for use at McMurdo and inland stations.

F. *R/V Hero*. *Hero* is a 38-meter-long wood diesel-powered research trawler equipped with sails. Launched in 1968, *Hero* operates in conjunction with Palmer Station to provide transportation, close support of science parties in the Antarctic Peninsula area, and experimentation using an on-board biological laboratory. In winter *Hero* sometimes supports research along the southern coasts of South America. *Hero* normally carries 12 crew and 8 scientists. *Hero* cruises at about 9 knots and has a range of 9,300 kilometers.

G. *Inflatable boats*. These 3- to 5-meter inflatable rubber open boats (Zodiacs) are used at Palmer Station and with *Hero*. They are powered by outboard motors.

H. *U.S. academic research ships*. As required and available, research ships of the U.S. academic fleet have worked in ice-free antarctic waters. Recent visitors have included *Melville*, *Knorr*, and *Alpha Helix*. Research projects generally are in the disciplines of physical oceanography, marine biology, and marine geology and geophysics.

I. *Ground transportation*. A variety of vehicles is used for transport and hauling. These include four-wheel-drive pickup trucks with oversize tires, allwheel-drive dump trucks and flatbeds, tracked vehicles, articulated vehicles with wide, low-pressure tires, and motor toboggans (snowmobiles). The familiar Caterpillar tractor is found in Antarctica—sometimes with low ground pressure wide tracks for improved operation on snow. Snowblowers and graders are used to clear snow from roads.

VI. Research objectives

Scientific investigation of Antarctica began on the present scale with the 1957-1958 International Geophysical Year, and, since then, continuous research by many nations has come close to completing a reconnaissance of the continent and its surrounding oceans.

The goal of the United States Antarctic Research Program is to foster research on worldwide and regional problems of current scientific importance and to expand fundamental knowledge of the region.

Research projects in the United States Antarctic Research Program are performed by investigators from universities and, to a lesser extent, from federal agencies and other organizations, and are supported by the National Science Foundation. Investigators may perform research and analysis individually, in small teams, or in large interdisciplinary groups.

Results of research in Antarctica are discussed in some of the references listed in section X. What follows is a brief description of research objectives in the five scientific disciplines most active in Antarctica:

A. *Glaciology*. The world's largest ice sheet covers 98 percent of the antarctic continent in thicknesses up to 4.8 kilometers. It is a vast storehouse of information about climate and atmospheric constituents and their variation over time. Research activities have been predominantly descriptive with emphasis on the extent of the ice sheet and its surface characteristics, such as temperature and snow accumulation. Some deformation measurements have been made. There is much to be learned through study of the internal characteristics of the ice sheet using, for example, radio-echo sounding, ice coring, and thermal probes. Ice cores have been drilled to bedrock and to shallower depths. Oxygen-isotope studies, use of radioactive isotopes for dating, analysis of fabrics, and chemical measurements can be pursued to extract paleoclimatic data. Surging glaciers are of keen interest to glaciologists. Although there are no known surging glaciers in Antarctica, a better understanding of of the range of physical conditions that cause surging and how close or how far the antarctic ice streams are from these conditions may be crucial to understanding the past and present dynamics of the ice cover of Antarctica, especially the west antarctic ice sheet. The present west antarctic ice sheet may be as young as 125,000 years old, while the east antarctic ice sheet could well be 25 million years old.

B. *Biological and medical research*. The biota of ponds and ice-free land areas of Antarctica is of special interest owing to the adaptations of its members to the extreme environment. In the ice-free valleys of southern Victoria Land biologists study bacteria, lichens, and algae living just beneath the surface of rocks, while other biologists investigate algae living in the region's ice-covered lakes. In the Antarctic Peninsula, biologists examine the cold adaptations of such antarctic insects as the wingless midge and of simple plant communities. The simplicity of these terrestrial ecosystems provides opportunities for analyses that are more difficult or impossible in the complex systems of lower latitudes.

The oceans surrounding Antarctica, in contrast to the land, comprise one of the richest biological regions on Earth, although the reasons for this unusual productivity are not yet fully understood. Studies of the marine ecosystem are the major part of the antarctic biology program.

Surveys and reconnaissance of the biota and habitats were largely completed in the late 1960s, and experimental and ecological studies have been emphasized since. Major attention is on ship- and shore-based studies of the structure and function of marine ecosystems, stressing trophodynamics and including detailed investigations of marine organisms at all trophic levels. Emphasis also is placed on studies of adaptation to antarctic environments, particularly to low temperatures.

Biomedical studies are directed towards understanding the epidemiology of viral infections in small, isolated groups of people at the stations and towards assessing physiological and psychological attributes of the same groups.

C. *Earth sciences*. Although geological maps have been prepared of many antarctic areas, geological reconnaissance of the continent is not yet complete. Nevertheless, research to date has provided a general outline of the region's geology and geophysics and has provided major clues in support of plate tectonics and the hypothesized Gondwana supercontinent. This research has pointed to the resource potentials of Antarctica, but it is not intended to identify or quantify deposits of resources.

Areas of special interest are the mountainous regions with significant ice free areas. These include the McMurdo Sound vicinity (including the dry valleys of southern Victoria Land), the central Transantarctic Mountains, the Scotia Arc, the Lassiter Coast, northern Victoria Land, the Dufek Intrusion (Pensacola Mountains), Marie Byrd Land, the coast of Ellsworth Land, the Ellsworth Mountains, and the continental shelf. The glacial geology of West Antarctica is of continuing interest, and work to date has provided a history of glacial activity in the Ross Sea region.

D. *Atmospheric sciences*. Unique studies of the Earth's magnetosphere and of Sun-Earth relationships are possible in Antarctica because of its physically stable location at high geomagnetic latitude. Objectives in studying the upper atmosphere in Antarctica are to improve understanding of the Earth's upper atmosphere and its near and far space environment, and to investigate solar-terrestrial effects on man and the human environment. Most of the upper atmosphere physics research is performed at Siple Station, which is ideally situated for studies of the plasmapause region of the magnetosphere using very low frequency and ultra low frequency waves as diagnostic tools. South Pole Station is in an ideal location for study of the sun, the aurora, and the cusp region of the magnetosphere.

In meteorology, Antarctica is Earth's largest heat sink, with its ice sheet containing about 90 percent of the world's glacial ice. As such, it is believed to play an important role in the planet's weather and climate. Research objectives are to improve understanding of the physical processes characteristic of the atmosphere over Antarctica, to determine the relationship between the antarctic atmosphere and global circulation and to determine Antarctica's role in past and present global climate. Much of the research in meteorology and atmospheric chemistry is performed at South Pole Station, but some is done at the other stations and aboard the LC-130 airplane specially equipped for meteorology and air chemistry. Automatic weather stations are used to collect data at several remote locations. At South Pole Station, a clean-air sampling facility enables studies of atmospheric aerosols and trace gases and monitoring of changes in climate and in background levels of world atmospheric constituents including pollutants.

E. *Ocean Sciences*. Because of large-scale heat losses at high latitudes, the southern ocean is a major source of cooler intermediate and deep water masses that circulate throughout the world oceans. Nutrient-rich waters support high biological activity. Large annual variations in temperature and the extent of sea ice profoundly influence energy transfer processes. The sea floor around Antarctica presents fundamental problems in marine geology and geophysics. A major objective is to support physical, geological, and geophysical studies and to investigate the relationship between oceanic and atmospheric circulation systems and the physical basis for the biological productivity of antarctic waters. A circum-antarctic survey from 1962 to 1979, in which the ice strengthened ship *Eltanin* made 66 cruises covering 521,000 nautical miles, provided much basic information and a framework for the current continuing program of problem-oriented ship-based research.

VII. Agency responsibilities

The United States Antarctic Research Program is the Nation's program for research and presence in Antarctica. It is funded and managed by the federal government, with agency responsibilities as follows.

A. *Antarctic Policy Group* serves as the policy guidance body for the totality of U.S. activities under the Antarctic Treaty (described below). Its membership consists of the Secretary of State (chairman), the Director of the National Science Foundation, the Secretary of Defense, or their designees, and representatives of other agencies as appropriate.

B. *National Science Foundation* has overall funding and management responsiblity for the U.S. activities in Antarctica. This responsibility involves several functions:

- Annual preparation of plans and budget for consideration within the Executive Branch and for review and appropriation by the Congress.

- Development of scientific goals for Antarctica, obtaining advice as needed from the scientific community and communicating these goals to the scientific community.

- Receipt of proposals for research projects from U.S. universities, other research institutions, and federal agencies; evaluation of these proposals for relevance to program goals, scientific merit, and logistics feasibility; and granting of funds (as available) to these institutions for performance of the projects in Antarctica and completion of analysis upon return.

- Detailed planning of logistics, and transmittal of logistics requirements and necessary funds to Naval Support Force Antarctica and United States Coast Guard (functions are described below).

- Development and management of a contract with a commercial firm (currently ITT Antarctic Services, Inc., Paramus, New Jersey) for operation of South Pole, Siple, and Palmer Stations, R/V *Hero*, specialized functions at McMurdo Station, and other services.

- Arrangement of cooperative scientific and logistics programs with other Antarctic Treaty nations.

- Designation of a Senior United States Representative in Antarctica and on-site management of the field programs in Antarctica.

- Serving as the clearinghouse and source of information regarding antarctic records, files, documents, and maps maintained within agencies and nongovernmental organizations.

C. *Department of Defense* (United States Navy) assists in planning and carries out logistics requested and reimbursed by the Foundation and assures the continuing availability of essential logistics components. This function is performed principally by the Naval Support Force Antarctica and the Navy's Antarctic Development Squadron Six (VXE-6). Functions include:

- Operation of much of McMurdo Station.

- Operation of a squadron of seven LC-130 Hercules airplanes and six or seven UH-1N helicopters in support of science projects and resupply of inland stations.

- Arrangement for annual resupply of McMurdo by United States Navy ships.

- Communications between Antarctica and the United States.

- Safety and medical care for U.S. personnel in Antarctica.

- Operation of a staging base in Christchurch, New Zealand.

D. *Department of Transportation* (United States Coast Guard) provides icebreaker services, reimbursed by the Foundation. These services include:

- channel breaking in McMurdo Sound in advance of the annual ship resupply of McMurdo Station.

- annual resupply of Palmer Station.

- support of on-board science projects.

Each icebreaker has an on-board aviation detachment consisting of two HH-52 helicopters used for ice reconnaissance, some cargo operations, and support of science projects.

E. *Department of State*, in addition to chairing the Antarctic Policy Group, is responsible for the formulation of foreign policy and the provision of foreign policy direction relating to the development and implementation of an integrated U.S. program for Antarctica; for the conduct of foreign relations regarding Antarctica; and for legal matters relating to the interpretation and implementation of the Antarctic Treaty.

F. ***Budget***. In fiscal 1981, the budget for United States activities in Antarctica, appearing in the National Science Foundation budget, was as shown in the table.

Budget, U.S. Antarctic Program, fiscal 1982 (estimated)

U.S. Antarctic Research Program:	
Atmospheric sciences	$1,950,000
Biological sciences	2,100,000
Earth sciences	1,348,000
Glaciology	1,029,000
Oceanography	1,303,000
Information and advisory services	770,000
Total	$8,500,000
Operations support program:	
Direct science support	$10,100,000
Base level support	39,442,000
Major construction and procurement	7,958,000
Total	$57,500,000
Total, U.S. Antarctic Program	$66,000,000

VIII. International cooperation

A. *Antarctic Treaty*. The Antarctic Treaty, signed at Washington, D.C., in 1959 and entered into force in 1961, establishes a legal framework for the area south of 60°S, which includes all of Antarctica. There are 14 Antarctic Treaty consultative nations; these nations are empowered to meet periodically and to influence operation of the treaty. They are Argentina, Australia, Belgium, Chile, Federal Republic of Germany, France, Japan, New Zealand, Norway, Poland, South Africa, Soviet Union, United Kingdom, and United States of America. There are (in December 1981) 11 acceding nations; these nations agree to abide by the treaty, but, not being among the original signatories and not having substantial programs in Antarctica, do not participate in the consultative process. These nations are Brazil, Bulgaria, Czechoslovakia, Denmark, Germany Democratic Republic, Italy, Netherlands, Papua New Guinea, Peru, Romania, and Uruguay.

The treaty provides that Antarctica shall be used for peaceful purposes only; it prohibits military operations except in support of peaceful activities. It provides that freedom of scientific investigation and cooperation shall continue and that nations shall exchange program plans, personnel, observations, and results. The treaty does not recognize, dispute, or establish territorial claims, and it prohibits assertion of new claims. It prohibits nuclear explosions and disposal of radioactive waste. It guarantees access by any treaty nation to inspect others' stations and equipment.

The consultative meetings provided for by the treaty have contributed recommendations, most of which have been formally adopted by the treaty nations, that provide rules for operating on the continent. One of the most significant is the Agreed Measures for the Conservation of Antarctic Fauna and Flora, ratified by the United States as Public Law 95-541, the Antarctic Conservation Act of 1978. Other significant advances have included the Convention for the Conservation of Antarctic Seals and the Convention on the Conservation of Antarctic Marine Living Resources. Negotiation toward a regime regarding exploration for and exploitation of minerals is under way.

B. *Scientific Committee on Antarctic Research (SCAR)*. SCAR is a committee of the International Council of Scientific Unions (ICSU), a nongovernmental organization. As stated in its constitution, SCAR is "charged with furthering the coordination of scientific activity in Antarctica, with a view to framing a scientific program of circumpolar scope and significance." Membership consists of a representative from each country engaged in antarctic research, representatives of other ICSU organizations as appropriate, and the World Meteorological Organization. Other international organizations may designate observers to attend meetings of SCAR. For the United States, the national committee adhering to SCAR is the Polar Research Board of the National Academy of Sciences.

SCAR meets every 2 years in a SCAR country (the next meeting, in 1982, will take place in Leningrad) to consider various scientific and logistics objectives and accomplishments. It also sponsors or associates with major symposia on antarctic subjects. Sometimes SCAR establishes working groups to develop information or reports in response to Antarctic Treaty recommendations. An example is a 1979 report on possible environmental effects of mineral exploration and exploitation, developed in response to a recommendation made at the 1975 Antarctic Treaty consultative meeting.

C. *Bilateral and multilateral cooperation*. Within the context of the Antarctic Treaty, extensive international cooperation takes place in Antarctica to more effectively accomplish both science projects and logistics. Some examples are exchanges of personnel among stations, cooperative planning and execution of large-scale science projects such as deep rock core drilling and glaciological exploration, and the exchange or shared use of logistics assets such as ships and aircraft. The United States has pursued cooperative projects with every Antarctic Treaty nation.

IX. U.S. policy for Antarctica

U.S. goals and policy regarding Antarctica have demonstrated a consistency over many decades as documented in numerous policy reviews and statements. Representative of this policy is a statement, issued by the White House on 13 October 1970, that says in part:

"The United States policy in Antarctica includes several objectives:

"• To maintain the Antarctic Treaty and ensure that this continent will continue to be used only for peaceful purposes and shall not become an area or object of international discord.

"• To foster cooperative scientific research for the solution of worldwide and regional problems, including environmental monitoring and prediction and assessment of resources.

"• To protect the antarctic environment and develop appropriate measures to ensure the equitable and wise use of living and nonliving resources.

"The Treaty has provided an effective framework for the continued peaceful use of the area by the twelve nations conducting research and working together on the icy continent, an area as large as the United States and Europe together, where national differences are no barrier to practical and mutually beneficial cooperation. . . . Science has provided a successful basis for international accord, and the Antarctic is the only continent where science serves as the principal expression of national policy and interest."

In 1982 the White House reaffirmed the policy, noting that the U.S. presence in Antarctica shall include "the conduct of scientific activities in major disciplines" and "year-round occupation of the South Pole and two coastal stations."

X. Past U.S. antarctic expeditions

A. *Before International Geophysical Year*

United States expeditions to Antarctica have occurred almost since the beginning of the nation. Among the notable ones, in 1820 Nathaniel Palmer, a Connecticut sealer, saw the Antarctic Peninsula from his 14-meter sloop *Hero*. John Davis made the first known landing on Antarctica, at Hughes Bay, in 1821. James Eights, a scientist, provided remarkably advanced natural history reports after accompanying sealers to the South Shetlands in 1829-1831. Charles Wilkes headed a Navy expedition that in 1839-1840 explored and mapped the coast of Wilkes Land and established that Antarctica is a continent. Carl B. Eielson piloted the first airplane flown in Antarctica, in 1928. Richard E. Byrd introduced largescale mechanization of antarctic exploration in two expeditions, in 1928-1930 and 1933-1935, that included extensive exploration by airplane and the first flight over the South Pole. Lincoln Ellsworth flew across Antarctica in 1935 and discovered the American Highland in 1938-1939. The government established two antarctic stations in 1939-1941 that were intended to begin a continuing antarctic service (World War II ended this plan). In 1946-1947 the Navy's Operation Highjump, the largest expedition ever made to Antarctica, used 13 ships, several helicopters and airplanes, and 4,700 men; it performed extensive aerial photography for mapping. A smaller Navy expedition, Operation Windmill, followed in 1947-1948. Finn Ronne's expedition in 1948 established a wintering station and explored and mapped at the base of the Antarctic Peninsula.

B. *International Geophysical Year, 1957-1958*

The International Geophysical Year, 1 July 1957 to 31 December 1958, was a great cooperative endeavor by the world's scientists to improve their understanding of the earth and its environment. Much of the field activity took place in Antarctica, where 12 nations established some 60 research stations.

The United States established six research stations—Little America, Hallett, South Pole, and Byrd (described in section III), plus Wilkes (on the coast of Wilkes Land, East Antarctica) and Ellsworth (on the Filchner Ice Shelf). Naval Air Facility, McMurdo Sound (now McMurdo Station), was set up as a logistics base from which to supply South Pole. Studies were directed toward geophysics and upper atmosphere physics and included simultaneous observations at all parts of the globe. In addition, long scientific traverses were made to collect data in glaciology, seismology, gravimetry, and meteorology. Geological and biological samples were collected, although these disciplines were not formally part of the IGY.

At the close of the IGY, it was recognized that many scientific problems merited continued attention, and most of the IGY antarctic nations decided to continue their research. The United States established its United States Antarctic Research Program, which has operated continuously to this day.

XI. For further information

A. *Maps, aerial photographs, gazetteer*

The U.S. Geological Survey has prepared and published, and offers for sale, reconnaissance maps of portions of Antarctica at scales of 1:250,000 and sketch maps at 1:500,000. Maps at other scales also are available. An index of these maps is available free from the U.S. Geological Survey, 1200 South Eads Street, Arlington, Virginia 22202. Ask for "Index to Topographic Maps Antarctica." Maps cost approximately $2 each.

Aerial photographs and maps produced by the United States and foreign nations are available for inspection at the U.S. Geological Survey, 507 National Center, Reston, Virginia 22092.

An annotated gazetteer of the approximately 12,000 antarctic place names recognized by the United States is available from the Government Printing Office, Washington, D.C. 20402 ($13, Stock No. 038-000-00471-5).

A total of 37 hydrographic charts of antarctic coastal and deep sea waters at scales from 1:500,000 to 1:5,000 are available from the Defense Mapping Agency, Office of Distribution Services, Washington, D.C. 20315.

B. *Bibliographies*

Since 1950, two bibliography projects have provided virtually complete coverage of the antarctic literature.

An ongoing ***Antarctic Bibliography*** prepared by the Library of Congress abstracts and indexes the world antarctic literature published between 1951 and the present.

As of September 1981, 29,927 titles had been cited in the subject categories of: general, biological sciences, cartography, expeditions, geological sciences, ice and snow, logistics equipment and supplies, medical sciences, meteorology, oceanography, atmospheric physics, terrestrial physics, and political geography. Author, subject, geographic, and grantee indexes are included.

Twelve hardbound volumes and a cumulative index have been published to date and may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402.

An ***Antarctic Bibliography*** prepared by the U.S. Naval Photographic Interpretation Center in 1951 has been reprinted and is available for $18.50 from the Greenwood Press, 51 Riverside Avenue, Westport, Connecticut 06880 (tele. 203/226-3571). The 147-page hardbound volume lists and indexes some 5,500 titles, covering the scientific, technical, and popular literature published from the earliest times to 1951.

C. *Background and reference materials*

Most results of antarctic research are published as papers in scientific journals, which are referenced in the *Antarctic Bibliography*. The following books and articles have been selected, somewhat arbitrarily, as representing the history and present status of antarctic exploration and research.

1. *History*

Little America (1930, 420 p.), *Discovery* (1935, 405 p.), and *Alone* (1938, 296 p.), by Richard E. Byrd (New York, Putnams). The first two are the official narratives of the first and second Byrd expeditions. The third described Byrd's vigil alone on the Ross Ice Shelf.

The Worst Journey in the World, by Apsley Cherry-Garrard (New York: Dial Press, 1930). A member of Scott's expedition describes a winter journey from McMurdo Sound to Cape Crozier.

Cold. The Record of an Antarctic Sledge Journey, by L. M. Gould (New York, Brewer, Warren, and Putnam, 1931).

Quest for a Continent, by Walter Sullivan (McGraw Hill, 1957). 357 p. History of antarctic exploration to late 1950s.

Endurance, Shackleton's Incredible Voyage, by Alfred Lansing (New York, McGraw Hill, 1959). 284 p. Shackleton's 2-year adventure.

Antarctic Conquest: The Great Explorers in Their Own Words, edited by Walker Chapman (Bobbs Merrill, 1965). 368 p. Anthology.

Americans in Antarctica 1775-1948, by Kenneth J. Bertrand (New York, American Geographical Society, 1971). 554 p. Authoritative history of U.S. involvement.

Antarctica: Authentic Accounts of Life and Exploration, edited by Charles Neider (New York, Random House, 1972). 464 p. Anthology plus editor's personal narrative.

Little America: Town at the Bottom of the World, by Paul

A. Carter (New York, Columbia University Press, 1979). 301 p. History emphasizing Byrd's expeditions.

Scott and Amundsen, by Roland Huntford (New York, G. P. Putnam's Sons, 1980). 665 p. Comparative biography.

2. *General*

A Continent for Science, by Richard S. Lewis (New York, Viking Press, 1965). 300 p. General.The Antarctic, by H. G. R. King (New York, Arco, 1969). 276 p. General.

Frozen Future: A Prophetic Report from Antarctica, edited by Richard S. Lewis and Philip M. Smith (Quadrangle Books, 1973). 454 p. Antarctica as political and scientific laboratory.

Encyclopedia Britannica, "Antarctica." 1975 (18 p.) or 1973 (16 p.) edition.

Polar Regions Atlas, by Central Intelligence Agency, Washington. Government Printing Office, 1978. Stock no. 041-015-00094-2. 68 p.

3. *Current activities*

The Sea and the Ice, by Louis J. Halle (Boston, Houghton Mifflin, 1973). 286 p. Personal narrative of a voyage by icebreaker.

Edge of the World: Ross Island, Antarctica, by Charles Neider (Doubleday, 1974). 461 p. Personal and historical narrative.

Life at the Bottom: The People of Antarctica, by John Langone (Boston, Little, Brown, 1977). 262 p. Anecdotal narrative.

Antarctica, by Eliot Porter (New York, E. P. Dutton, 1978). 169 p. Eighty-seven color photographs plus text.

Flight 901 to Erebus, by Ken Hickson (Christchurch, New Zealand, Whitcoulls, 1980). 278 p. Air New Zealand DC-10 crash.

The New Explorers: Women in Antarctica, by Barbara Land (New York: Dodd, Mead, 1981). 224 p.

"A reporter at large (Antarctica): South of 60 degrees south," by Katherine Bouton. *The New Yorker*, 23 March 1981, p. 42-122.

4. *Science*

Research in the Antarctic, edited by Louis O. Quam (Washington, AAAS, 1971). 768 p. Thirty-nine introductory and review papers on antarctic science.

Antarctic Map Folio Series (1964-1975), edited by Vivian C. Bushnell (New York, American Geographical Society). Nineteen folios of maps and charts supplemented by texts and extensive references. Subjects: aeronomical maps, the ice sheet, maps and surveys 1900-1964, climatology, magnetic and gravity maps, primary productivity and benthic marine algae, marine invertebrates, geologic maps, circumpolar characteristics of waters, birds, fishes, morphology of the earth, marine sediments, mammals, and history of exploration and scientific investigation. Some still available from Smithsonian Oceanographic Sorting Center, Washington, D.C. 20560.

Polar Research: To the Present, and the Future, edited by Mary A. McWhinnie (Washington, American Association for the Advancement of Science, 1978). 309 p. Twelve papers on physical and biological research.

Antarctic Research Series (1963). American Geophysical Union, 2000 Florida Avenue, N.W., Washington, D.C. 20009. Original refereed reports, too lengthy for the standard scientific journals, on results of recent scientific research in Antarctica.

Antarctic Journal of the United States (1966). Washington: National Science Foundation. $11 ($13.75 foreign) per year from Government Printing Office, Washington, D.C. 20402. Quarterly news plus annual reviews of United States Antarctic Research Program.

Frontiers (Autumn 1978). Academy of Natural Sciences of Philadelphia. Ten articles on research and resources in Antarctica.

Mosaic (September/October 1978). Washington: National Science Foundation. Articles on polar geology, glaciology, marine biology, meteorology, and upper atmosphere physics. Available from Government Printing Office, Washington, D.C. 20402.

Questions may be directed to the Polar Information Service, Division of Polar Programs, National Science Foundation, Washington, D.C. 20550. Telephone number: 202/357-7817.

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